Taxonomic radiation of chemosynthetic community during Cretaceous to Cenozoic: Background analysis by seep-carbonate anatomy

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Chemosynthetic ecosystem has kept much attention as an extinction-resistant refuge of Paleozoic and Mesozoic relics, due to its independency from sea-surface environmental fluctuations. In contrast, an alternative hypothesis has also been argued that chemosynthetic taxa underwent frequent extinctions and repid bursts of adaptive radiation. Fossil records suggests that the taxonomic compositon underwent major changes during the late Cretaceous to Cenozoic interval: 1) turnover of dominant megabenthos from brachiopods to bivalves in late Cretaceous, and 2) vesicomyid radiation in Cenozoic. However, its cause and background remain to be unclear.

The Japanese Islands is one of ideal areas to trace evolution of chemosynthetic communities, because of abundant fossil-records over 80 localities during the Cretaceous to Cenozoic as well as a large number of studies on living communities and their geo-tectonic settings by co-working of biology, geology, and geochemistry. This study focuses on relation between seep-activity and taxonomic structure of fossil assemblages, and shows two examples of chemosynthetic carbonate anatomy: 1) the lower Middle Miocene Bessho Formation in Northern Fossa Magna (explosive seep) and 2) the Plio-Pleistocene Kakegawa Group, Pacific-side fore-arc basin fill (diffusive seep).

The Bessho Formation consists of slope-silt facies and intercalates large limestone blocks (the Akanuda and Anazawa limestones). The limestone blocks are dstributed along the strike (NE-SW) of the surrounding siltstone, and the Anazawa limestone is a large-mound with its NE-SW axis over 100 m. The fossil assemblages are dominated by vesicomyids, and characterized by frequent occurrences of bathymodioline patches. The petrology is characteirized by 1) calcite veinlet-network in detrital micrite, which was corroded and isolated to be islands in the veinlets, and 2) large-scaled (over 30 cm in width) veins of fibrous and blocky calcite. These petrological features are recognized in the Recent carbonate mounds on the Canadian shelf (Matsumoto, 1990) where explosive methane-seepage resulted in carbonate dissolution through aerobic oxidiation of methane. The fossil chemosynthetic assemblages commonly containing epifauna (e.g., tube worms, articulated brachiopods, or mytilid bivalves) are frequently associated with this explosive-type carbonates, such as the Canadian Arctic Cretaceous (Beauchamp and Savard, 1992), the Jurrasic to lower Cretaceous in the convergent margin of California, USA (Campbell et al., 2002), and the upper Miocene Ogaya Formation in Northern Fossa Magna, Japan (Amano, 2003).

Slope-silt facies of the Kakegawa Group also yields chemosynthetic fossil assemblages dominated by vesicomyid fossils, but the associated carbonates are small-scaled (granular to a few meters in diameter) and irregular-shaped. The fossil assembalge is different from those of the Bessho Formaiton in rare occurrence of bathymodioline bivalves. The carbonates are composed of detrital dolomicrite and lacks large-scaled vains of fibrous cement. The corrosion of micritic cement is limited in small cavity-walls such as burrows in which fibrous aragonite crystals grew. Thses suggest that the carbonates were formed by diffusive seepate in underground condition, in case of which the seepage did not directly supply methane into oxic bottom water. Similar litho- and bio-facies are also recognized in the Upper Miocene Morai Foramtion in Hokkaido.

The two case studies with similar examples suggest that vesicomyid clams adapted not only to explosive vents but also diffusive seepage conditions. Was the latter habitat an open-niche that triggered the Cenozic vesicomyid radiation? For the purpose of testing this hypothesis, relation between litho- and bio-facies of seep carbonates needs to be traced through geologic times.